Sentinel-2 Mission: Mission status and R&D preparations

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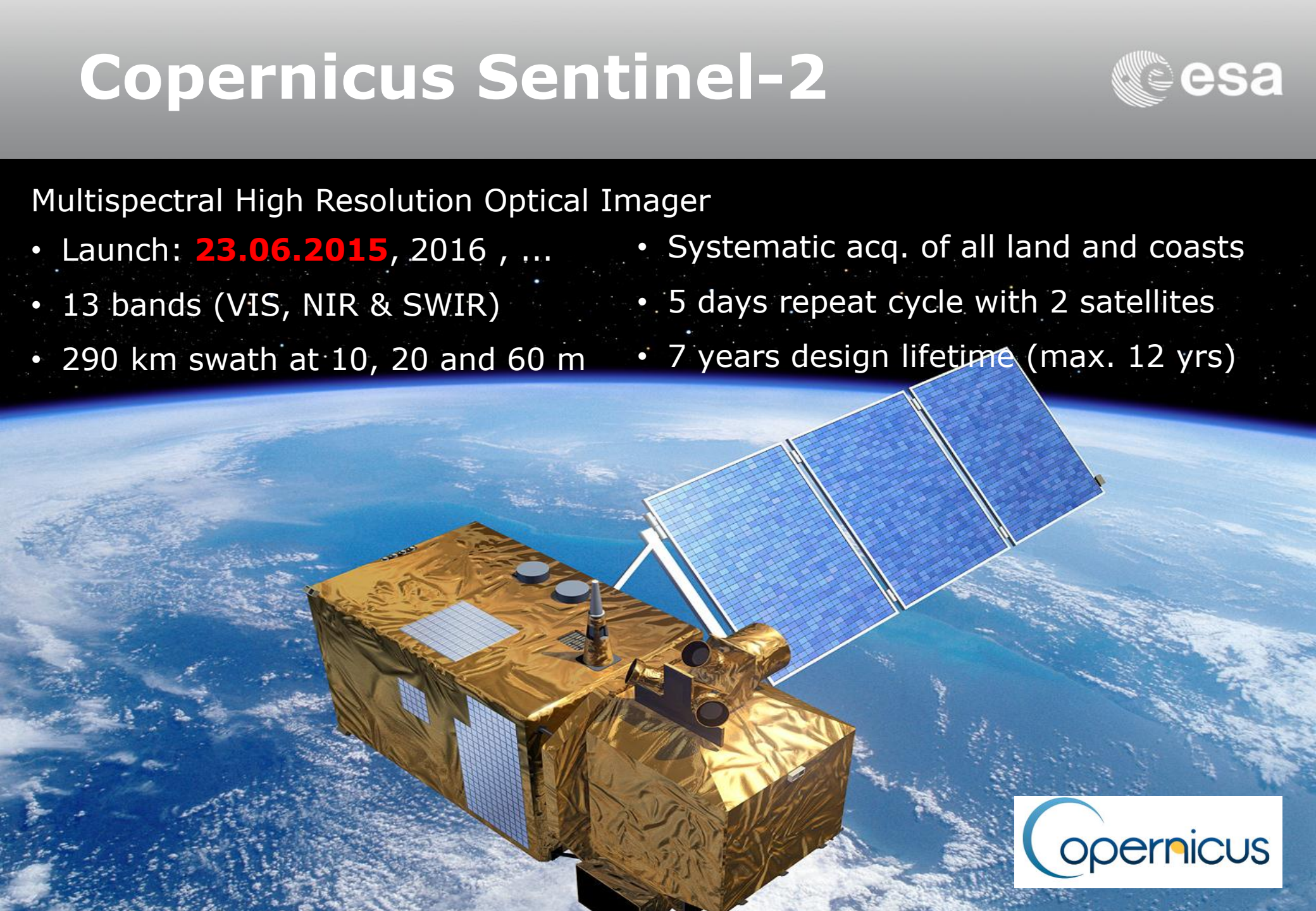
Copernicus Sentinel-2

Multispectral High Resolution Optical Imager

- Launch: **23.06.2015**, 2016 , ...
- 13 bands (VIS, NIR & SWIR)
- 290 km swath at 10, 20 and 60 m
- Systematic acq. of all land and coasts
- 5 days repeat cycle with 2 satellites
- 7 years design lifetime (max. 12 yrs)



Launch Preparation

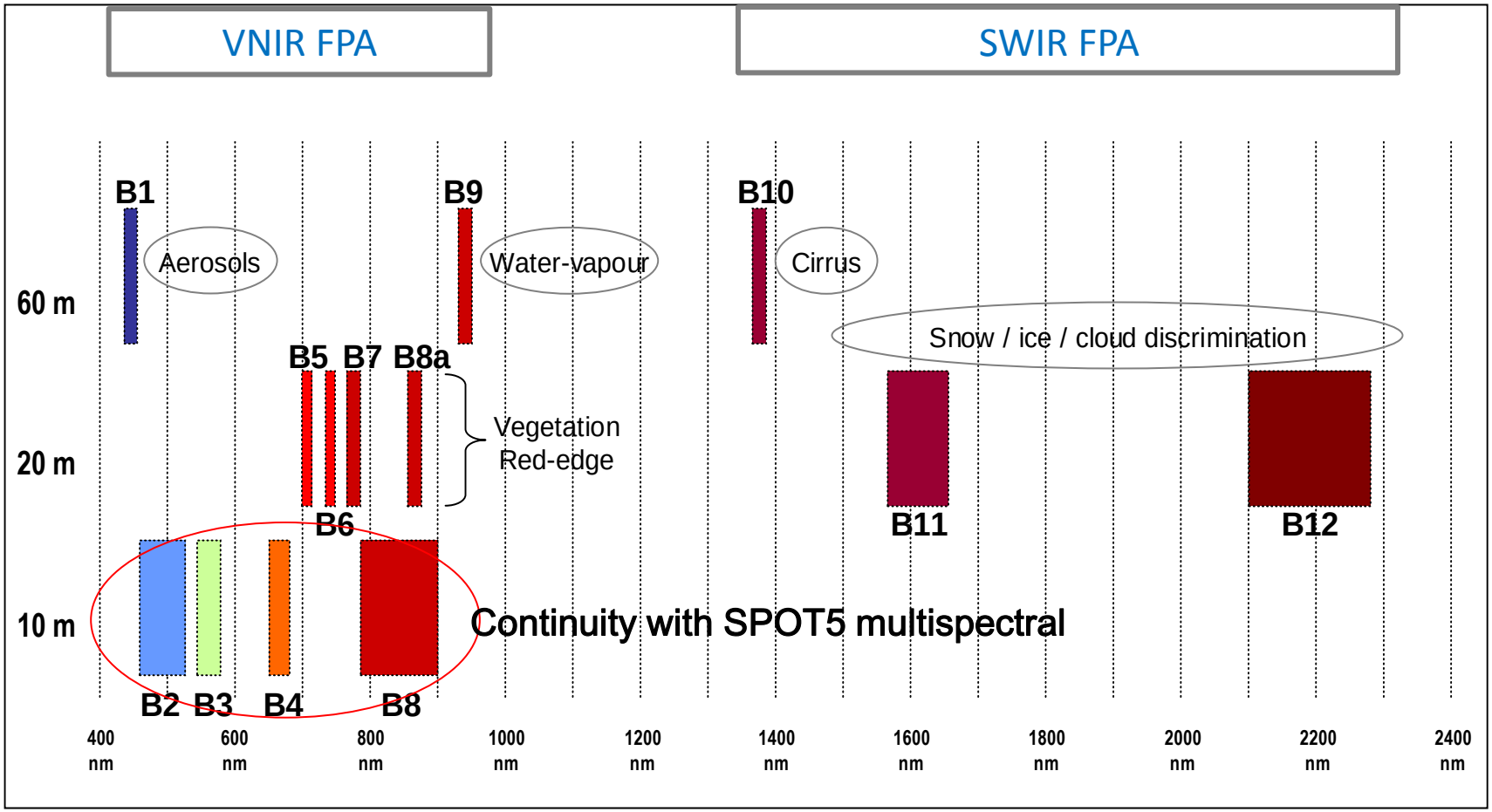
→ SENTINEL-2A ENCAPSULATION
AND INTEGRATION ON VEGA VV05

SENTINEL-2 LAUNCHED!

Sentinel-2 Mission Status

- **Nominal Status** within the commissioning phase
- **Platform:**
  - Launch Early Operation Phase concluded in 3 days
  - Reached reference orbit
- **Sensor:**
  - MSI – fully functional, under calibration
- **Ground segment:**
  - 2 ground stations connected (Matera, Svalbard)
  - 1st image acquired 100h after launch (27.06.2015, 10:30)
  - Operational Processor – functioning nominal
  - IOCR planned at launch +3 months

Sentinel-2: MSI spectral bands



Landsat 8
OLI bands

Sentinel-2 Products

Name	High-level Description	Production	Preservation Strategy	Volume
Level-1B	Top-of-atmophere radiances in sensor geometry	Systematic	Long-term	~27 MB (each 25x23km^2)
Level-1C	Top-of-atmosphere reflectances in cartographic geometry	Systematic	Long-term	~500 MB (each 100x100km^2)
Level-2A	Bottom-of-atmosphere reflectances in cartographic geometry (prototype product)	On user side* (using Sentinel-2 Toolbox**)	N/A	~600 MB (each 100x100km^2)

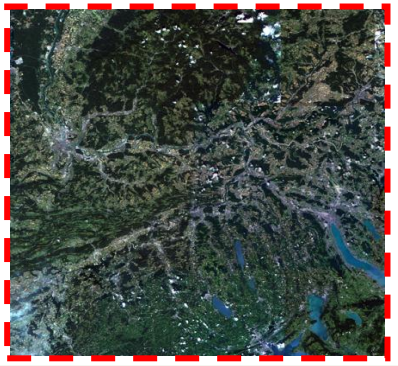
*: The possibility of a systematic global production of L2A is currently being explored.
**: https://sentinel.esa.int/web/sentinel/toolboxes/sentinel-2

Level-1C / Definition

- Top-of-atmosphere (TOA) reflectance in cartographic geometry (UTM/WGS84).
- Image radiometry key features:
  - ✓ Radiometrically corrected data.
  - ✓ Reflectance coded in 12 bits.
  - ✓ Product includes all necessary parameters required to convert the provided reflectance into radiances.
- Image geometry key features:
  - ✓ Orthorectification uses an 90m-resolution DEM

PlanetDEM http://www.planetobserver.com/products/planetdem/planetdem-90/

  - ✓ Sub-pixel multi-temporal registration between images.



100km x 100km tile

Level-1C / Algorithm

Level-0

TELEMETRY ANALYSIS

PRELIMINARY QUICK-LOOK AND CLOUD MASK GENERATION

Level-0 Consolidated

DECOMPESSION

SWIR PIXELS REARRANGEMENT

Level-1A

RADIOMETRIC CORRECTIONS

- Inv. on-board equalization,
- Dark signal correction,
- Blind pixels removal,
- Cross-talk correction,
- Relative response correction,
- Defective/no-data correction,
- Deconvolution/Denoising,
- Binning of 60m bands.

GEOMETRIC VIEWING MODEL REFINEMENT

- Refining of the viewing model using a global set of reference images,
- Registration between VNIR and SWIR focal planes (optional).

Level-1B

RESAMPLING

- Geometry interpolation grid computation,
- Resampling (B-splines).

CONVERSION TO REFLECTANCES

PREVIEW IMAGE AND MASKS GENERATION (defective pixels, cloud & land/water)

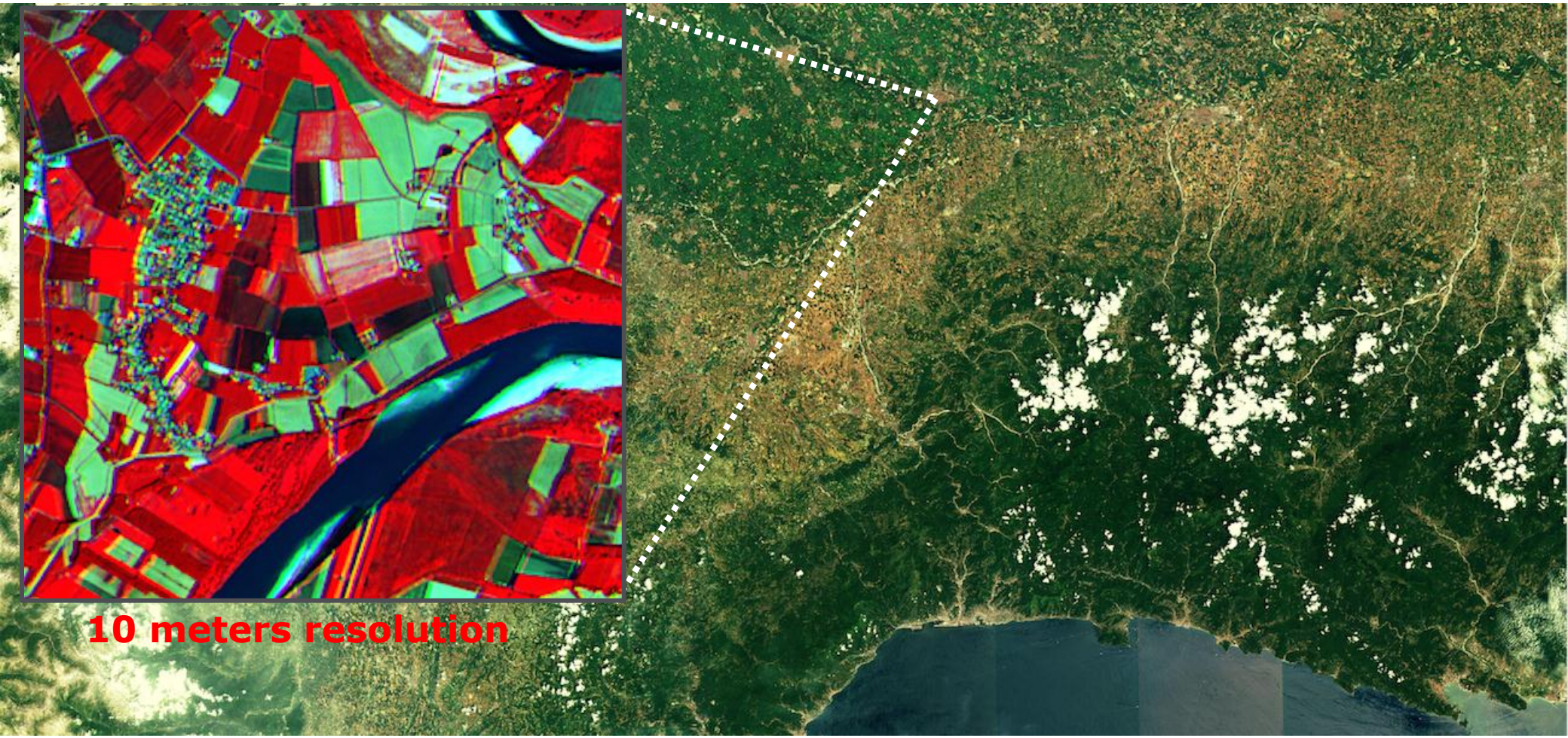
Level-1C

Level-1C / Data Quality Targets

Radiometric Data Quality	
Absolute radiometric uncertainty	3 % (goal) , 5 % (threshold)
Inter-band relative radiometric uncertainty	3%
Linearity knowledge accuracy	1%
Modulation Transfer Function (MTF)	0.15 to 0.3 (for 10m bands) <0.45 (for 20 & 60m bands)
Geometric Data Quality	
Absolute geolocation uncertainty	20m 2σ (threshold) 12.5m 2σ (goal) with GCPs
Multi-temporal registration	0.3 pixel 2σ (goal) with GCPs
Multi-spectral registration (for any couple of spectral bands)	0.3 pixel 3σ

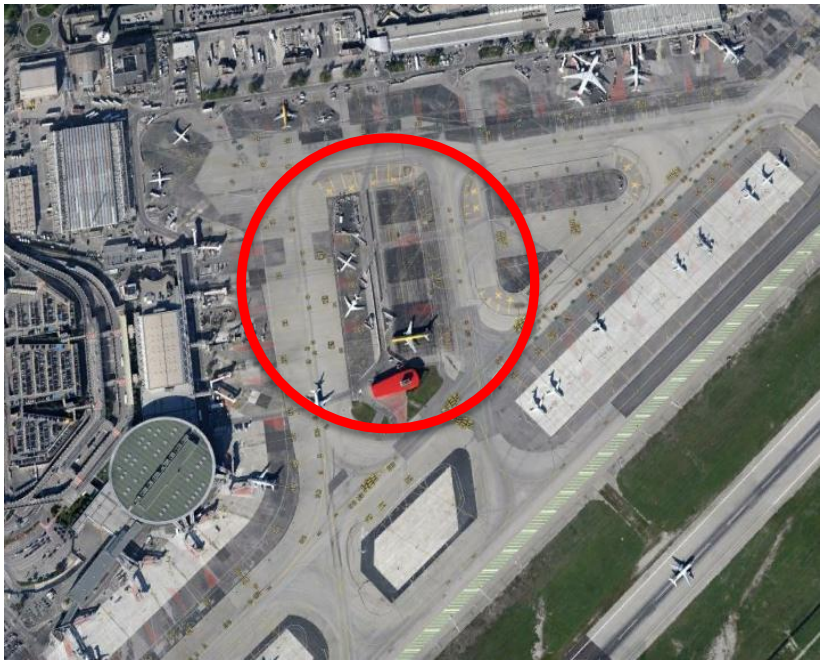
Sentinel-2 Swath & resolution

First S2 image – 27th of June 2015



French Riviera

Nice, France
Infrastructure mapping



Saint Tropez
Marine & costal applications

Milano
Urban mapping

MILANO 2015
European Space Agency

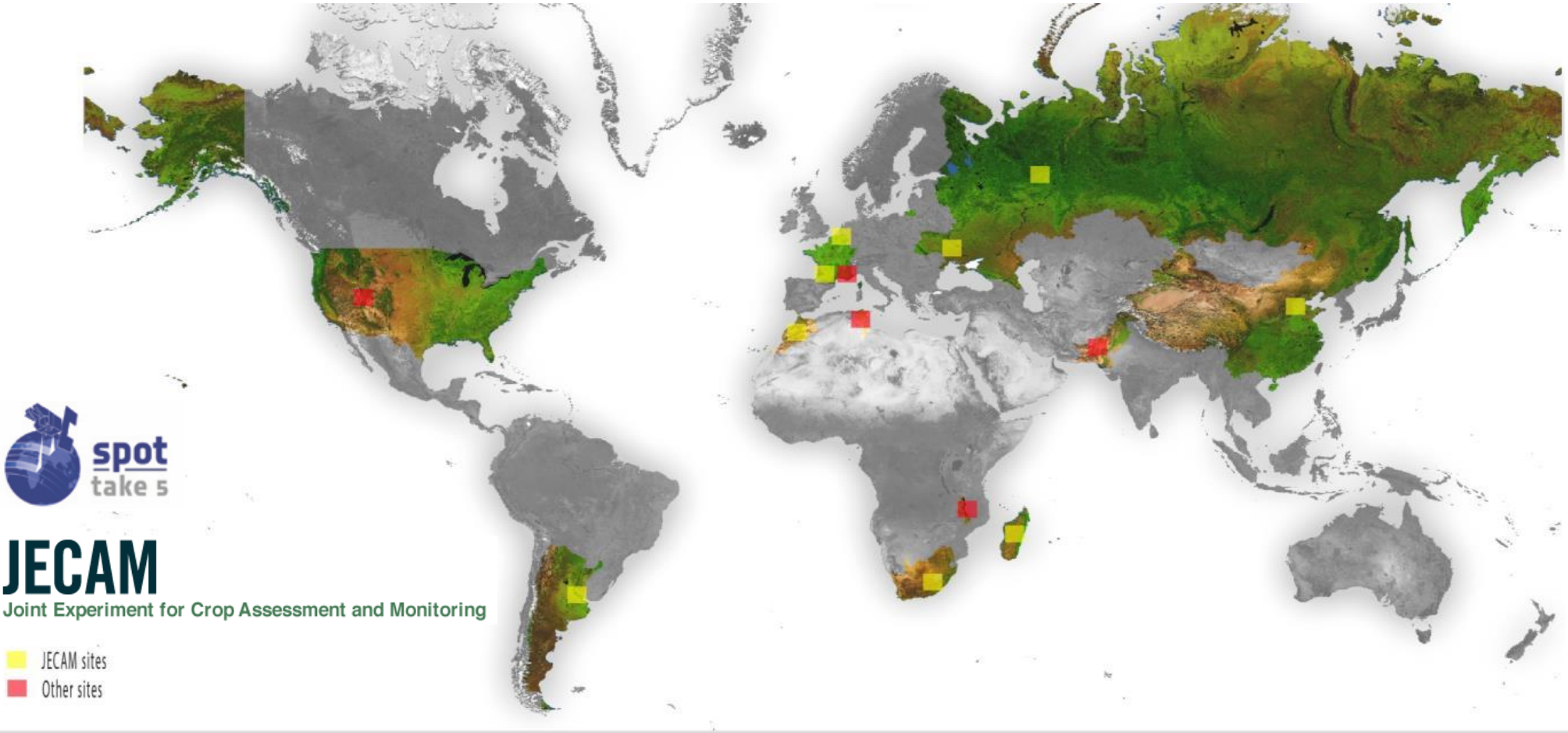
Pavia (Po valley)
Agricultural monitoring at field scale

sentinel-2

→ AGRICULTURE

Algorithm development & Product prototyping:
12 globally distributed sites

esa



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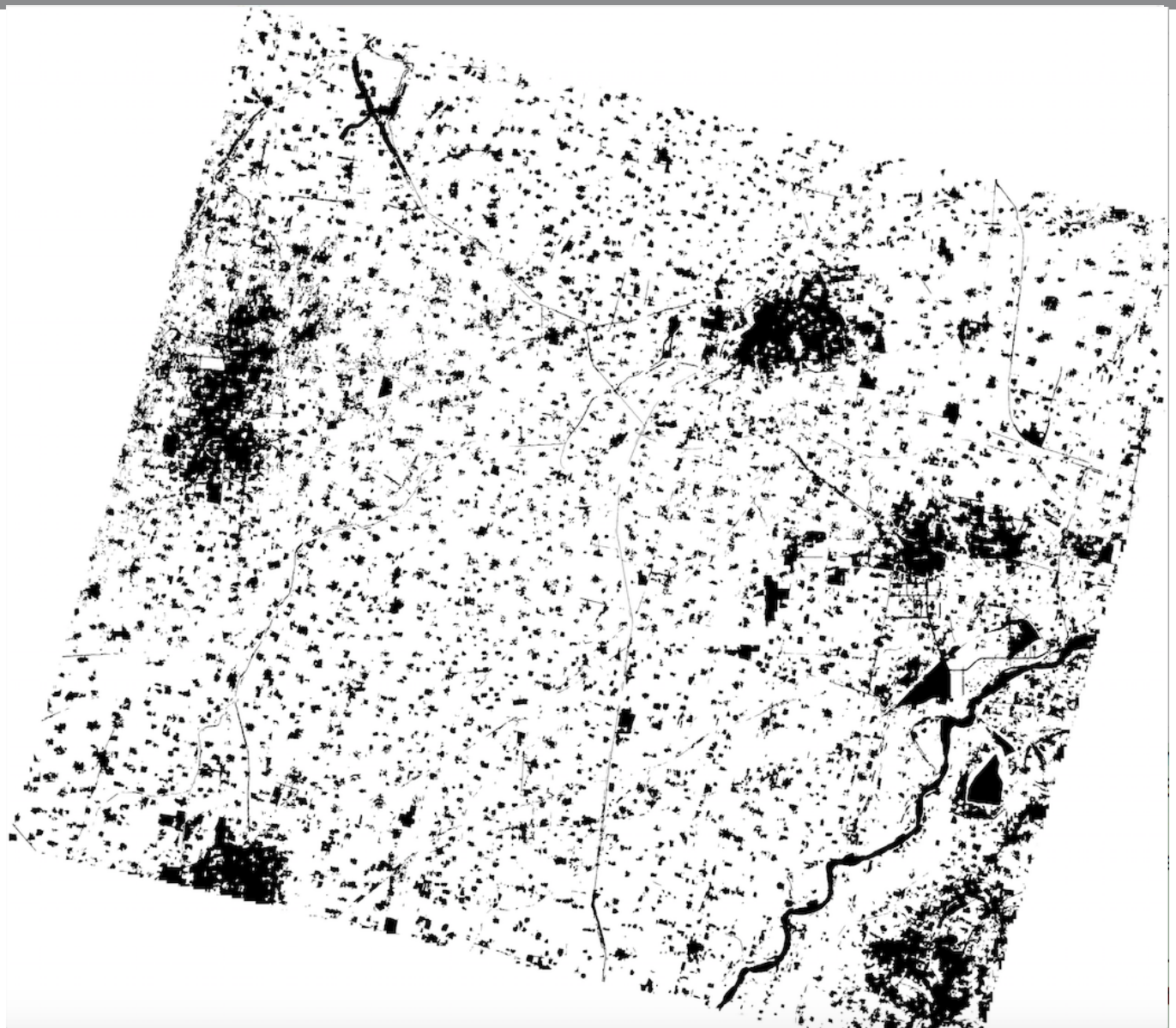
sentinel-2

→ AGRICULTURE

Dynamic Crop mask
JECAM site: Shandong, China

esa



RADI

European Space Agency

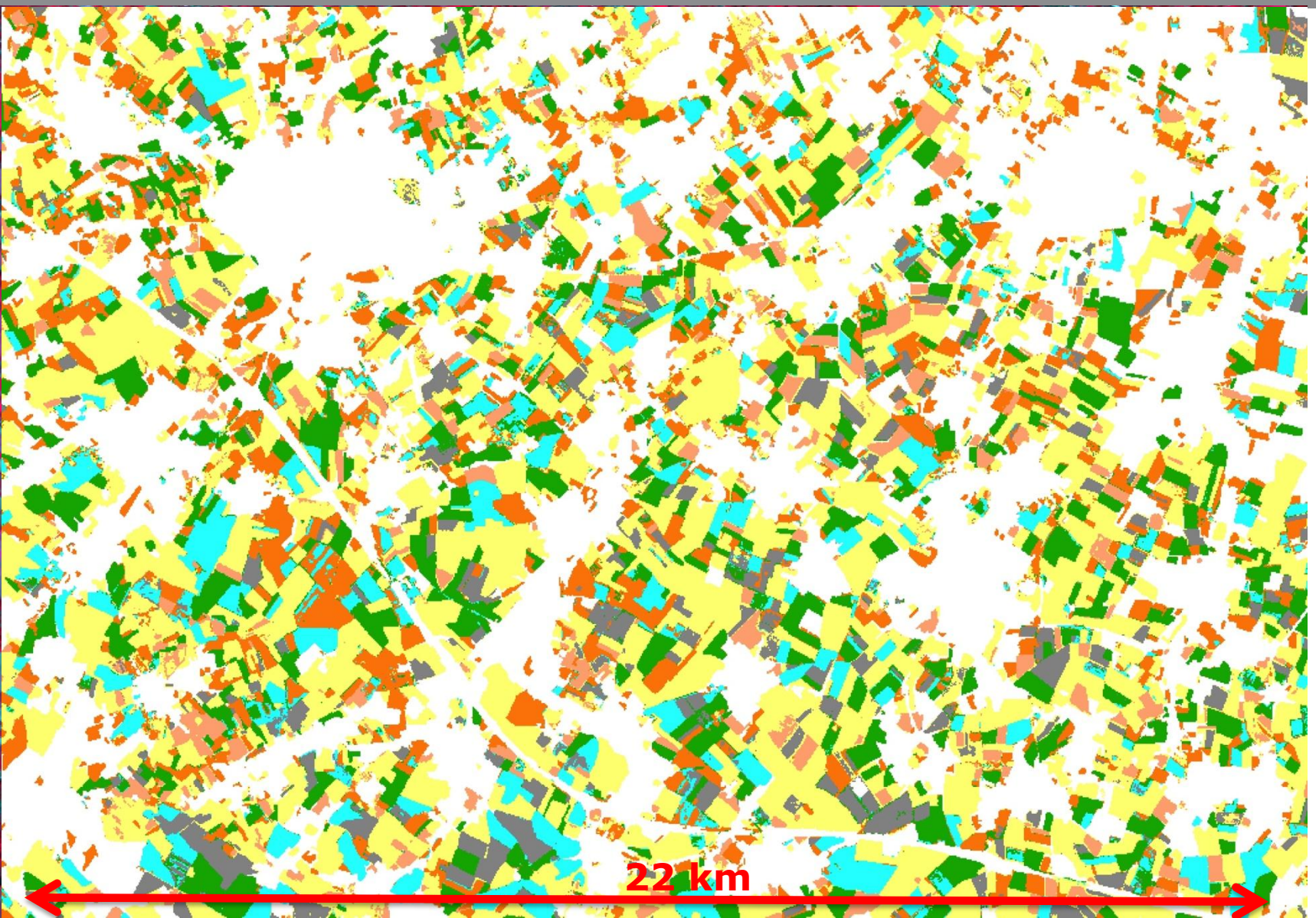
sentinel-2

→ AGRICULTURE

Crop type and area estimate

JECAM site: Belgium

esa



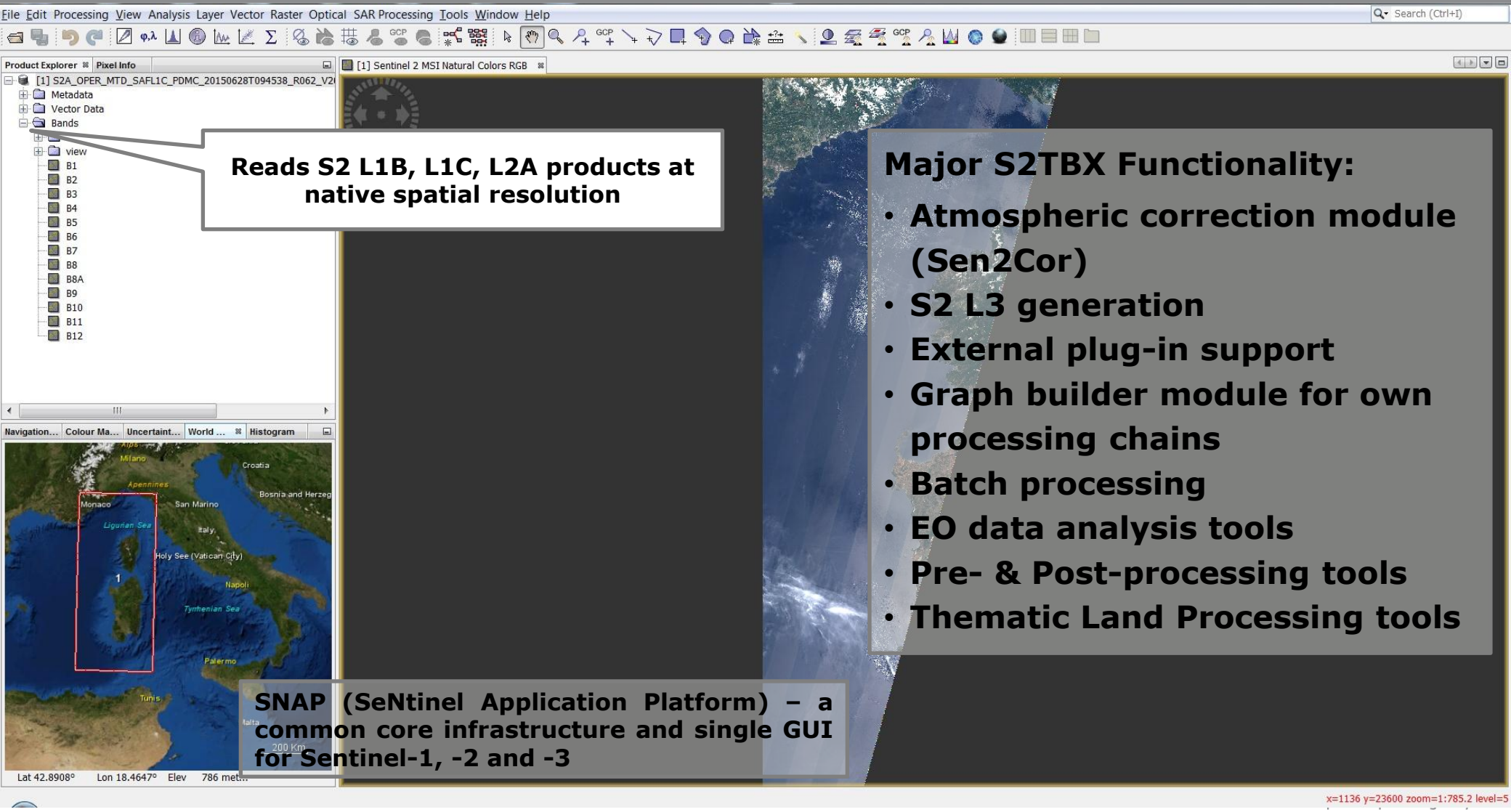
Legend

- No crop
- Maize
- Potatoes
- Sugar beet
- Winter wheat
- Winter barely
- Other annual crops

UCL Université catholique de Louvain

European Space Agency

Sentinel-2 Toolbox
Open-source scientific software



Reads S2 L1B, L1C, L2A products at native spatial resolution

Major S2TBX Functionality:

- **Atmospheric correction module (Sen2Cor)**
- **S2 L3 generation**
- **External plug-in support**
- **Graph builder module for own processing chains**
- **Batch processing**
- **EO data analysis tools**
- **Pre- & Post-processing tools**
- **Thematic Land Processing tools**

SNAP (SeNtinel Application Platform) – a common core infrastructure and single GUI for Sentinel-1, -2 and -3

SNAP beta version: http://step.esa.int/main/download/

Level-2A / Definition

Bottom-of-atmosphere (BOA) reflectance in cartographic geometry (UTM/WGS84)

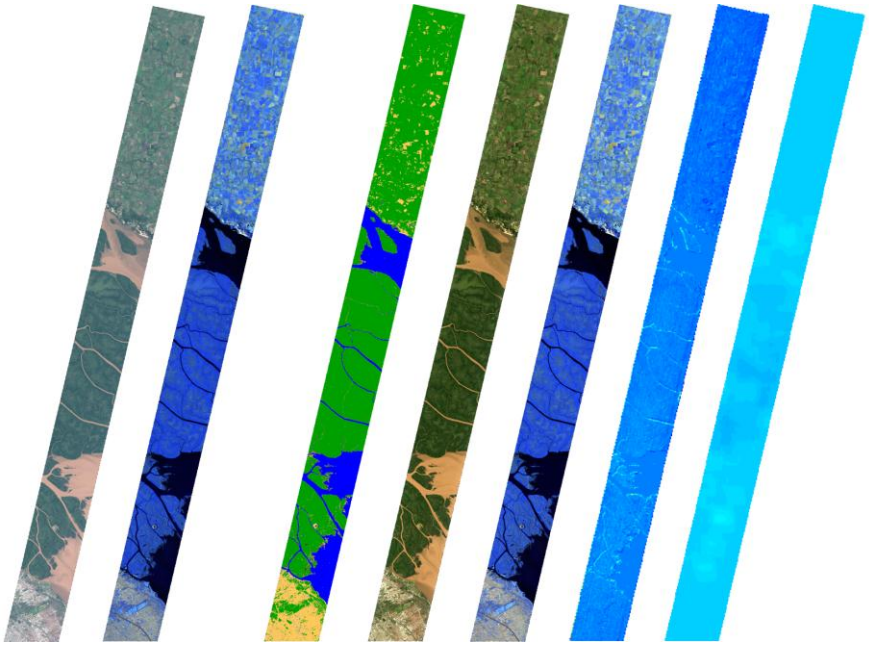
→ ESA is preparing for systematic L2a processing

Products additionally include:

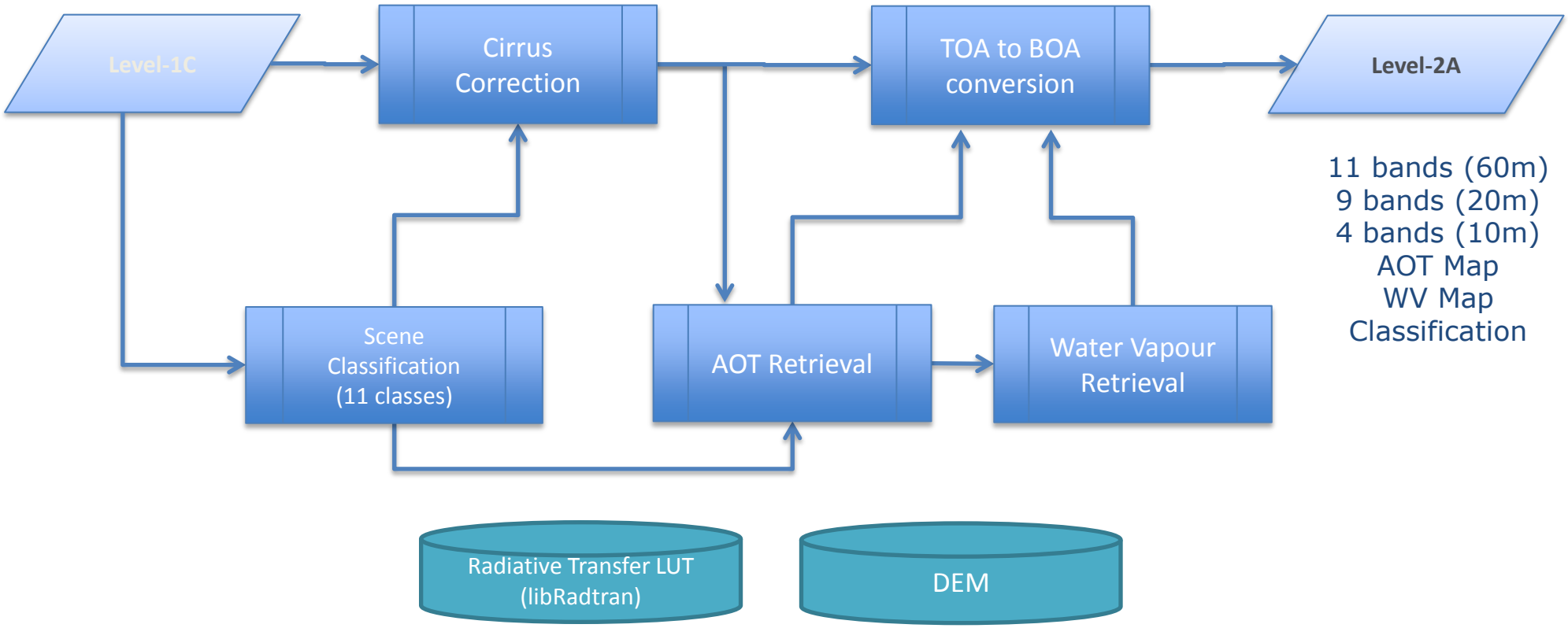
- ✓ Scene Classification Map
- ✓ Water Vapour Map
- ✓ Aerosols Optical Thickness Map

Algorithm includes:

- ✓ Cloud and cloud shadow detection.
- ✓ Cirrus detection and correction.
- ✓ Slope effect correction.
- ✓ BRDF effect correction.



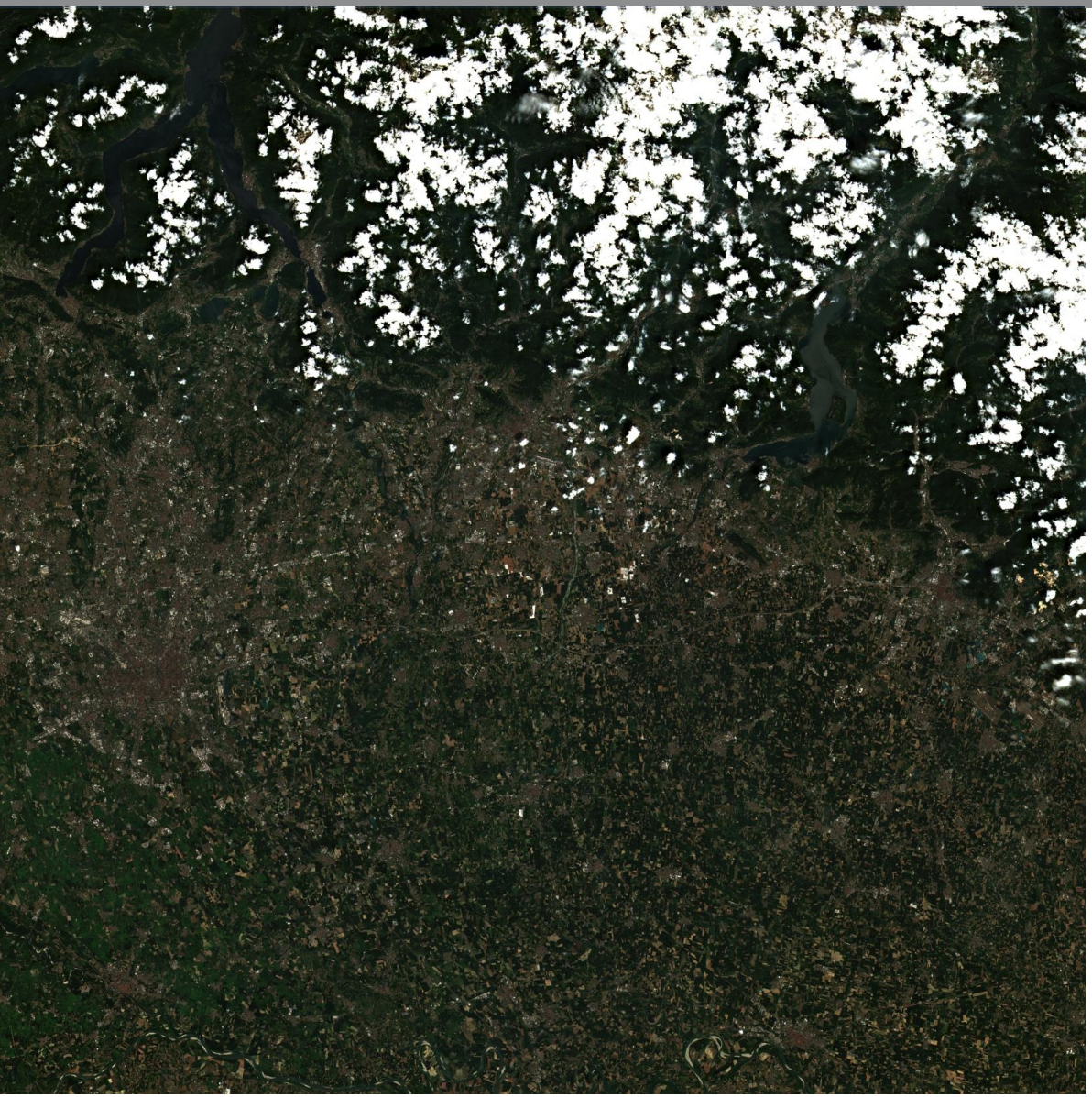
Level-2A / Algorithm Overview

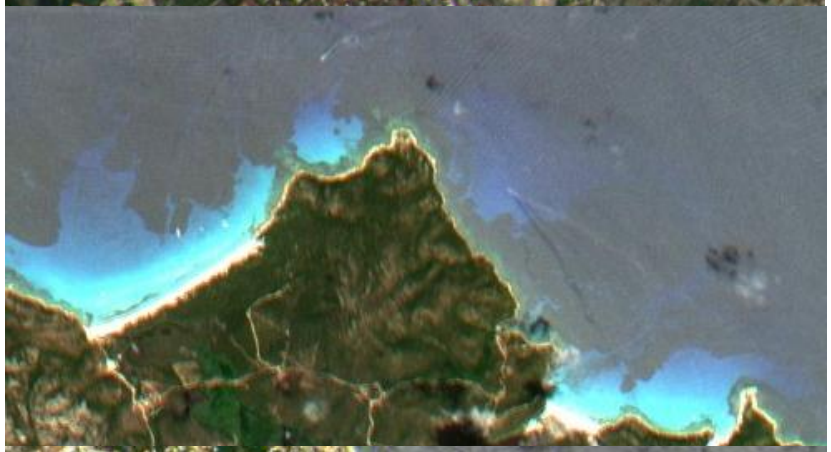


Algorithms developed with

DLR TELESPAZIO

First L2a Sentinel-2 products





SPOT5-Take5
S2 simulated time series

- SPOT5 acquisitions **every 5 days** - April to September 2015
- L1c & L2a data over 150 sites – free access: https://spot-take5.org/

Time Series Analysis for **new information products:**

- High resolution vegetation anomalies
- Forest degradation and latest logging activities (roads)
- Seasonal water bodies dynamics
- High resolution turbidity of costal and inland waters

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Special Issue "Lessons Learned from the SPOT4 (Take5): Experiment in Preparation for Sentinel-2"

Quicklinks

http://www.mdpi.com/journal/remotesensing/special_issues/spot4

ESA-NASA Sentinel-2 & Landsat
Research Cooperation

Common S2 & L8 Research community

- Recurrent (annual) scientific workshops alternating between US and Europe
- Focus on S2 & L8 synergy & products
- Supported by NASA and ESA research activities (e.g. tools, portable archives)

Coordination of ESA & NASA research activities

- Coordination of parallel research calls from ESA and NASA on land imaging (e.g. Multi-Source Land Imaging and DUE Innovator calls)
- Set up of an international Land Imaging Science Team with focus on L8 & S2 synergy (TBD)

Mission-specific collaboration S2-L8

Pre-flight calibration was done prior to launch of L8

S2-L8 cross calibration

Other types of collaboration such as:

- Validation campaigns and cross-validation
- Joint observation campaigns such as
    - Joint campaigns e.g. Antarctica
    - Nighttime observations campaign for global volcanoes
    - Coral reefs or other natural features special campaigns
- Joint fused/synergy products & long-term product evolution
- DEM usage: ESA has received an offer from Airbus for use of WorldDEM – possible synergy with USGS
- GRI usage by L8, comparison between L8 GCP database with S2 GRI

Innovator Projects
R&D for Sentinel-1 & -2 applications

S2-4Sci Land & Water

SEOM call: 1.5 Meuro, Start Q3 2015
Objective: Algorithm development for Sentinel-2 products

- Study 1: Development & inter-comparison of innovative radiometric validation methods
- Study 2: Atmospheric corrections for coastal & inland waters
- Study 3: Land cover classification
- Study 4: Multi-temporal analysis – dynamic features & change detection
- Study 5: Coastal and inland waters – HR water quality for hydrodynamic modeling
- Study 6: Coral reefs – habitat mapping, change detection & S2 coral reefs observation scenario

PRAGUE 09-13 MAY 2016

esa

Multi-source Land Imaging special session?

living planet symposium | PRAGUE 09-13 May 2016

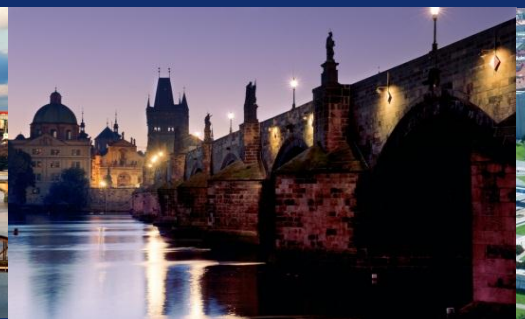
Main Objective:
Presentation of Exploitation Results based on ESA Earth Observation Measurements

Important Dates:

Deadline for abstract submission	16 October 2015
Notification of Acceptances	End January 2016
Issue of Preliminary Programme	February 2016
Opening of Registration to the Symposium	February 2016
Release of the Final Programme	at the symposium
Submission of Full Papers	at the symposium

Themes:
Atmosphere, Oceanography, Cryosphere, Land, Hazards, Climate and Meteorology, Solid Earth/Geodesy, Near-Earth Environment, Methodologies and Products, Open Science 2.0

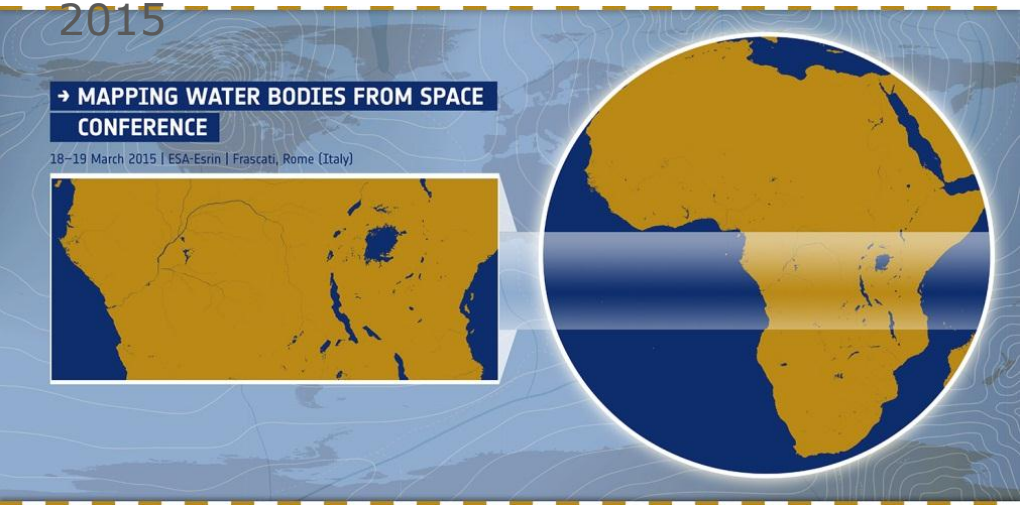
http://lps16.esa.int



Thematic workshops
Addressing specific user communities

- Address new **observations opportunities** offered by the **Sentinels** and other Space assets for major societal challenges
- shape the **next generation of R&D activities** in the frame of ESA Earth Observation Envelope Programme

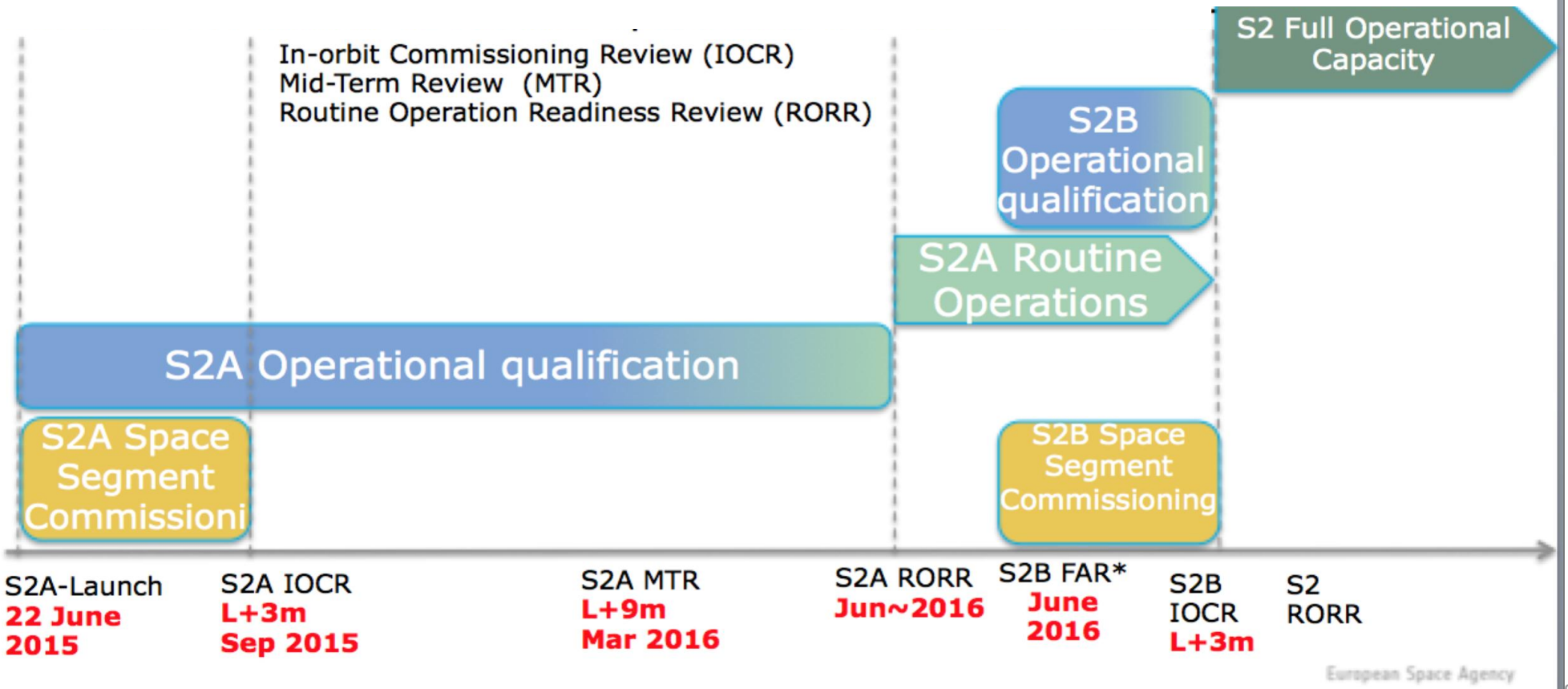
Mapping **Water Bodies** from Space
MWBS 15 18-19 March 2015



Mapping **Urban areas** from Space
MUAS 15 4-5 November 2015

Sentinel-2 Timeline
Major Milestones

Detailed planning of Ramp-up Phase:
https://sentinel.esa.int/web/sentinel/missions/sentinel-2/operations-ramp-up-phase



**S2B launch period committed with Eurockot between 1st Sept. and 30th Nov. 2016*

Sentinel-2 Data access

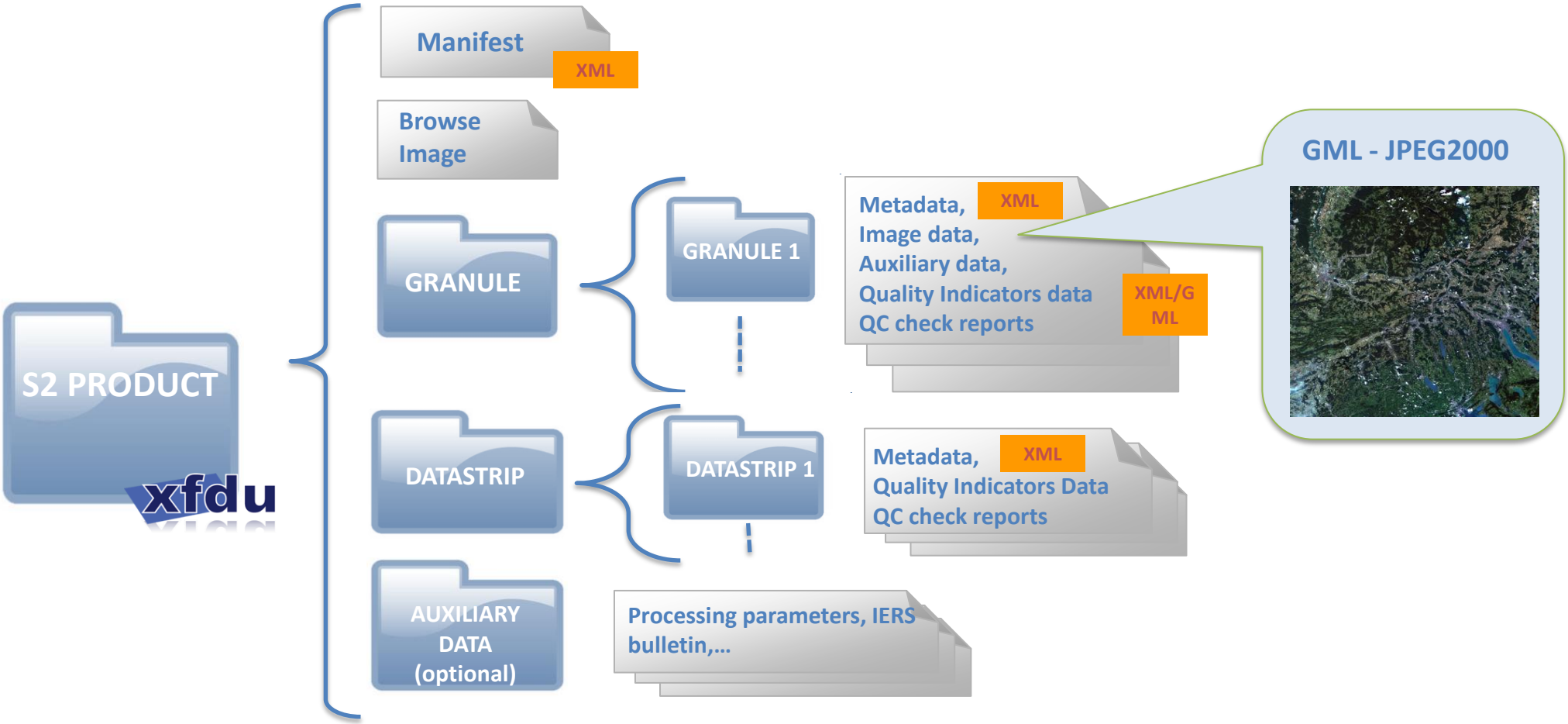
https://scihub.esa.int

- Release of reference data sets on the Science Data Hub
  - First publication of product sample THIS WEEK!
  - L1c product samples for different applications

Conclu

Date w.r.t Launch	Events, Milestones, Activities	Comment
Launch	Launch from Kourou on Vega	
From L to L + 3d	LEOP Phase End-of-LEOP Review (ELR), authorisation to start the In-Orbit Commissioning	Main objectives: - Appendages Deployments - Achievement of Satellite Nominal Mode and AOCS Nominal Pointing Mode - Switch ON and check of sub-system and MSI
L + 3d	Start of Satellite Commissioning	Main objectives: - Spacecraft in-orbit Verification - Orbit Verification - Ground System Interfaces Verification - MSI Calibration and Performance Verification - Calibration Facilities Verification - Verification of the OCP interface
From L+4w to L+6w	First images/key applications press event	The date of the press event will be communicated soon
L + 1 m	Start planning observations of Reference Datasets	Reference Datasets cover various applications domains, a precise list will be published on Sentinel Online
IOCR - 1 m	Release of detailed Sentinel-2 acquisition plans starting after IOCR	Detailed plan will cover typically 1-2 repeat cycles (10-20 days)
IOCR - 1 m	Start of distribution of Sentinel-2A reference products to all users (nominal case)	Announcement on Sentinel Online
L + 3 m	IOCR (In Orbit Commissioning Review) End of space segment (satellite and FOS) commissioning phase	Main objectives: - Verify that the objectives of the space segment commissioning phase have been fulfilled - Establish that the criteria of S1 space segment handover (see event below) are fulfilled
IOCR	Release of Level-1 pre-qualified products Start of gradual data provision of pre-qualified Level 1 to all users	

Products Format : Sentinel-SAFE



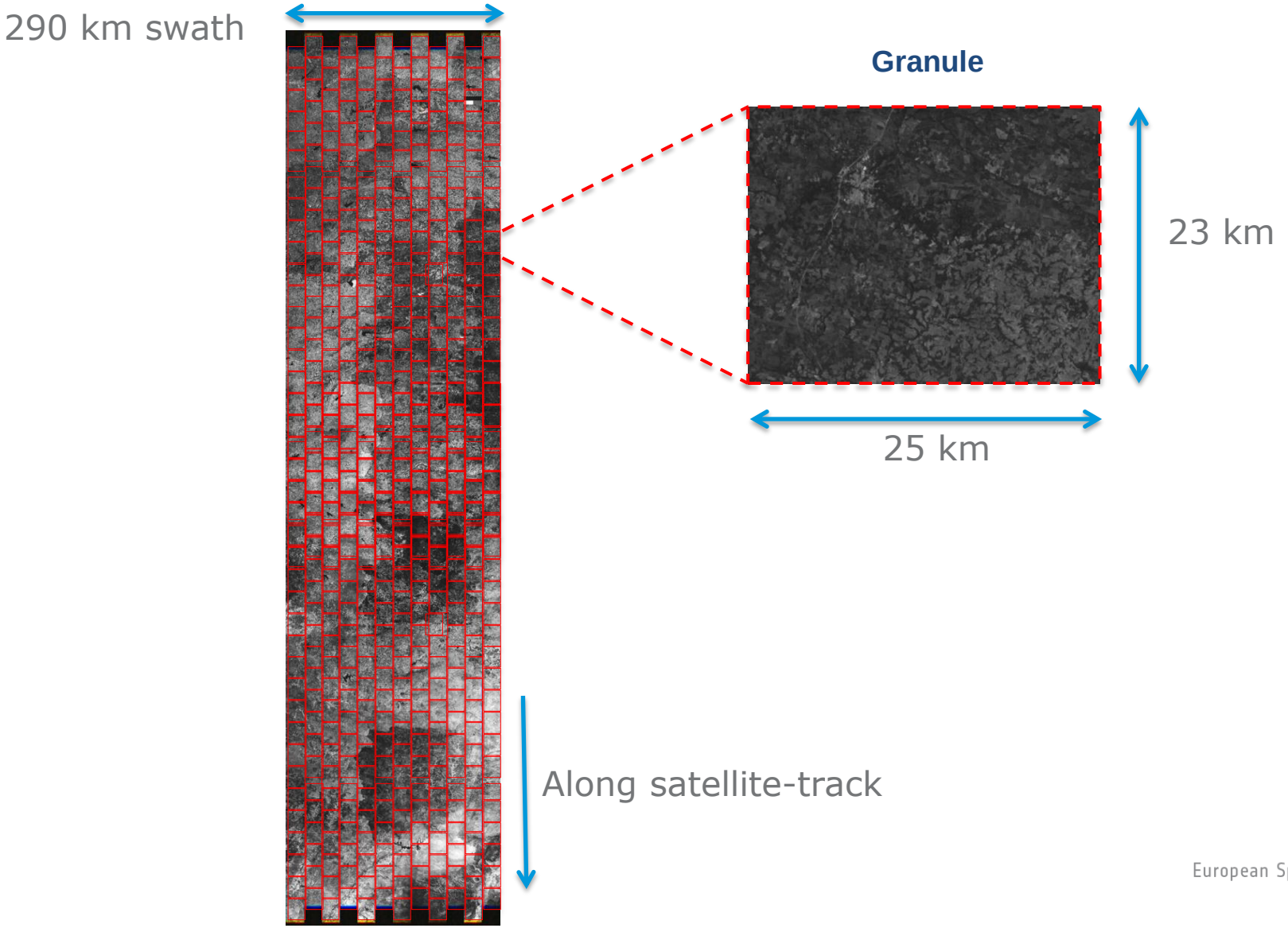
Level-1B / Definition

- Top-of-atmosphere (TOA) radiances in sensor geometry.

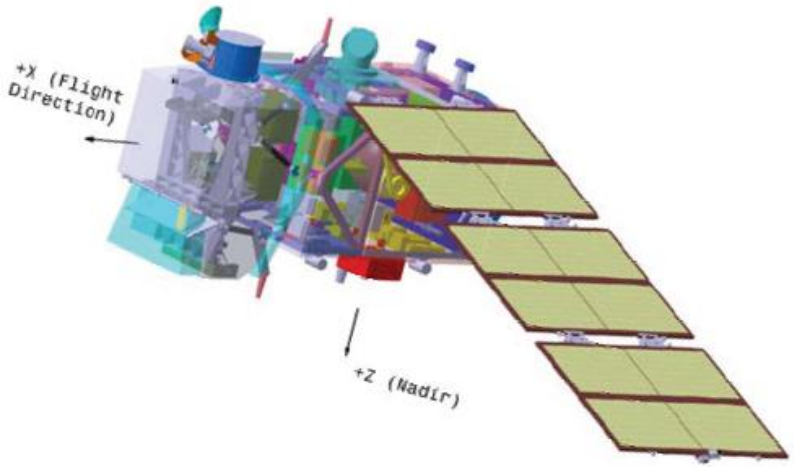
- Image radiometry key features:
  - ✓ Radiometric corrections for: dark signal, pixel response non-uniformity, defective pixels, etc.
  - ✓ Radiances coded in 12 bits.

- Image geometry key features:
  - ✓ Coarse registration between bands and between staggered detectors (no resampling).
  - ✓ Includes a refined geometrical viewing model calculated using a GRI (Global Reference Image).

Level-1B / Product Example

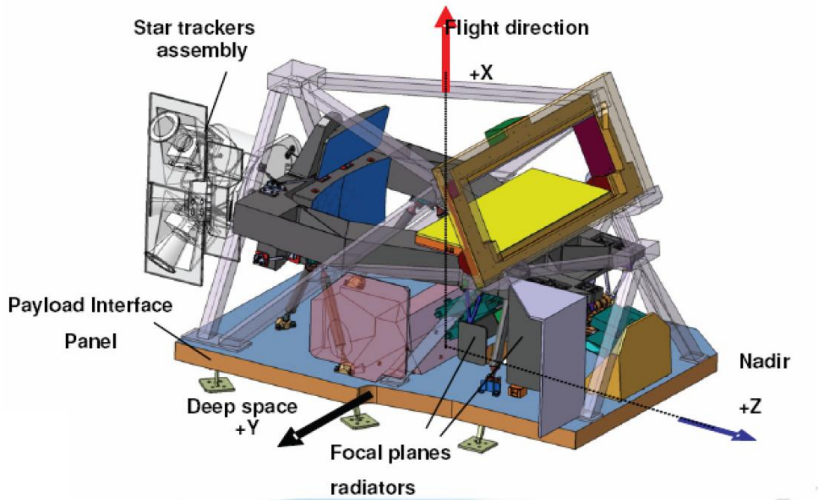


Satellite and Instrument



Satellite

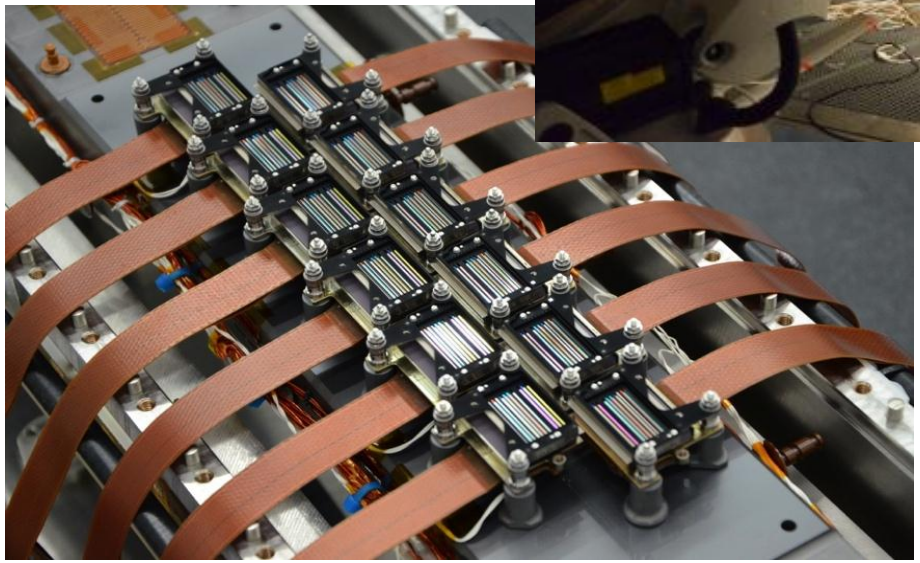
- Satellite mass: 1200 kg
- Satellite power consumption: 1250 W
- Hydrazine propulsion system (120 kg - including provision for safe mode, debris avoidance and EOL orbit decrease for faster re-entry)
- Accurate AOCS based on multi-head Star Tracker and fiber optic gyro
- X band mission data distribution (520 Mbits/sec)
- Mission data onboard storage: 2.4 Tbits

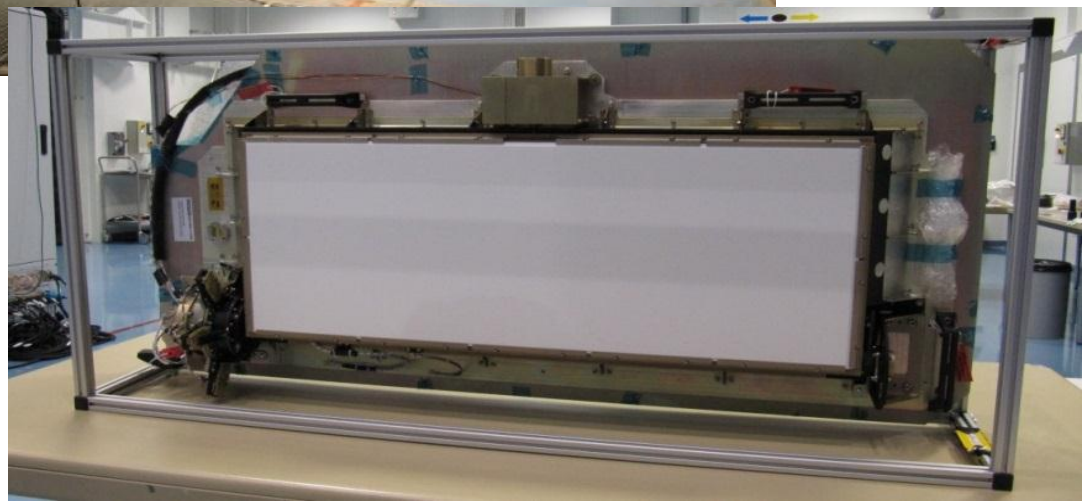


MultiSpectral instrument

- Filter based push broom imager (280 kg, 1 m^3)
- Three mirrors silicon carbide telescope, with dichroic beam splitter
- Focal plane arrays: Si CMOS VNIR detectors, HgCdTe SWIR detectors.
- Onboard wavelet compression (divided by 3)
- Integrated video & compression electronics (state of the art wavelet compression)
- Radiometric resolution 12bits
- Daily generated telemetry: 1.4 TB

Multi-Spectral Instrument (MSI)





Sentinel-2 & Landsat-8

Landsat-8: 20.06.2015

Sentinel-2: 27.06.2015